NAT'L INST. OF STAND & TECH

A11106 031635

NBSIR 85-3284

User's Guide for FAST

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U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards
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Center for Fire Research
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ABSTRACT

FAST is a multicompartment zone type computer model which predicts the smoke hazard development in each compartment based on a description of the compartments and the fire. A FORTRAN program has been written for the model. This user's guide provides a detailed description of the data input requirements and the output produced by version 17 of the program. Also included are sample program input and output.

Key Words: compartment fires; computer programs; fire growth; manuals; mathematical models; room fires; smoke; toxicity.

1. INTRODUCTION

In 1984 Walter W. Jones published a report describing a computer model for the transport of fire, smoke and toxic gases (FAST) [1,2][1]. The report describes the basic phenomena used in the model and a computer program (FAST Version 15) which performs the calculations. Although that report includes a sample input data set, it does not provide information about the input format and options. This user's guide supplements the initial report by providing a detailed description of the program input and output, as well as information on installing and running a slightly revised version of the program, FAST 17. This user's guide does not include a catalog of fire related materials property data. A recent report by Gross [3] provides examples and sources for such data.

1.1 Summary of the Model Features

FAST is a multicompartment control volume (zone) type fire model. It assumes that each room or compartment can be separated into volumes in which the properties such as temperature and pressure are relatively uniform. The two volumes of most importance to the user are the hot upper layer, sometimes known as the smoke layer, and the relatively cool lower layer. A schematic of the upper and lower layer control volumes is shown

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[1] Figures in brackets indicate literature reference at the end of this report.

in Figure 1. The primary purpose of FAST is to predict the conditions in the two layers as a result of a fire.

FAST considers the fire to be a source of heat and combustion products. The heat generation rate used by the program is the result of multiplying an effective net heat of combustion by a time varying rate of mass loss ("burning rate") of the fuel. Both of these values are user specified. The FAST model assumes that the fire burns at the rate specified by the user regardless of the conditions in the room.

The product or species generation rates are user specified inputs in terms of the rate a species is generated per unit mass loss of fuel. The generation rates may vary as a function of time. FAST has the ability to track a number of common fire species such as oxygen, nitrogen, carbon dioxide, carbon monoxide and smoke. As with the mass loss rate, the fire conditions do not affect the user specified species generation rates.

Using the specified heat and product generation rates and geometrical and thermophysical data, FAST solves equations for the conservation of mass, momentum and energy plus heat conduction and mixing within each control volume as a function of time. The results are the thickness and temperature of, and species concentration in, both the upper and lower layers in each compartment. Also given are the heat transfer and mass flow rates, and boundary surface temperatures.

1.2 Using the Computer Program

The FAST program consist of over 3000 lines of FORTRAN and is believed to adhere fully to the FORTRAN 77 standard [4]. The program source code is supplied on either magnetic tape or disk and includes information on installing the program. Users may require assistance from their local computer systems staff in installing the program. The procedure used to run the program will depend on the installation at a particular site.

The FAST program is written for "batch input." An input data file is prepared by the user with a text editor. This data file is then assigned as input to the FAST program. FAST does not prompt the user with questions concerning the input data. The following section of this paper describes the structure of the input data file.

2. DESCRIPTION OF THE INPUT DATA

The input must be grouped in the following order 1) Title and time step, 2) Configuration parameters, 3) Floor plan data, 4) Connections, 5) Thermophysical properties of the enclosing surfaces, 6) Fire specifications, 7) Species production, 8) Output file. Although the above sequence of groups must be followed, the sequence of the lines within the groups is not significant. The number of lines in a given data set will vary depending for example on the number of openings or the number of species tracked. A sample input data file is given in

Appendix A.   A number of parameters such as heat transfer and
flow coefficients   have   been   set   within   the   program   as
constants [1,2].

     Each line of input consists of a label followed by one or
more numerical values associated with that input variable.   The
label must always begin in the first space of the line and be in
capital letters.   If the label is less than five characters in
length, spaces must be added to the end of the label to complete
the required five character length.   Following the label, the
first of the values may start in any column and all values must
be separated by either a comma or a space.   Values may contain
decimal points if needed. Units are standard SI units except
energy (kJ) and power (kW).   In the following examples, the
symbol ˜ is used to indicate a space. The symbol 0 indicates the
number zero and the symbol O indicates the letter O.   FAST will
successfully run with the omission of some input lines or values.
These cases are indicated throughout this document.

2.1 Title and Timestep

VERSN

    INPUT:
        VERSN [Number] [Title]

    EXAMPLE:
        VERSN~~017~BUILDING XYZ

    NOTES:
        VERSN must be typed in to the first five spaces of the line followed by two blank spaces in columns six and seven and the number 017. [Title] is optional and may consist of letters, numbers, and/or symbols that may be entered in the next 50 spaces and permits the user to label each run.

TIMES

    INPUT:
        TIMES [Simulation time (sec)] [Print interval (sec)] [Dump interval (sec)]

    EXAMPLE:
        TIMES~360~30~10

    NOTES:
        [Simulation time] is the length of time over which the simulation takes place. The maximum value for this input is 86400 seconds (one day).

        [Print interval] is the time interval between each printing of the output values. In this example, the output will be printed for every 30 seconds of the simulation.

        [Dump interval] is the time interval between each writing of the output to the dump file. See Section 2.8. In this example, data will be written to the dump file for every ten seconds of the simulation. A zero must be used if no dump file exists.

2.2   Configuration Parameters

NROOM

    INPUT:
        NROOM [Number of rooms]

    EXAMPLE:
        NROOM~3

    NOTES:
        [Number of rooms] is the number of rooms (compartments)
        inside the structure to be analyzed. The maximum
        allowable number of rooms is 10 for version 17 of FAST.
        The space outside the structure is automatically
        numbered 1 greater than the specified number of rooms.
        In the above example, the outside would be room 4.
        Rooms in the structure which are not part of the
        analysis do not have to be numbered.

NMXOP

    INPUT:
        NMXOP [Maximum number of connections (openings)
        between any two rooms]

    EXAMPLE:
        NMXOP~1

    NOTES:
        [Maximum number of connections] is the maximum number
        of connections (openings) between any two rooms. For
        example, if two windows and one door connect adjoining
        rooms then 3 is used as the input. The [maximum number
        of connections] cannot exceed 4.

        The maximum number of connections is not a limit on the
        number of connections to a single compartment. For
        example if five rooms, each with a single opening, are
        all connected to the same room then the maximum number
        of connections is 1.

TAMB

     INPUT:
        TAMB~ [Ambient temperature (K)]

     EXAMPLE:
        TAMB~300

     NOTES:
        [Ambient temperature] is the temperature of the ambient
        atmosphere in Kelvin (Kelvin = degrees Celsius + 273).

2.3 Floor Plan Data

     INPUT:
        HI/F~ [Floor height (m)]
        WIDTH [Room width (m)]
        DEPTH [Room depth (m)]
        HEIGH [Room height (m)]

     EXAMPLE:
        HI/F~~~0.0~~0.0~~0.0
        WIDTH~~6.1~~4.6~~4.6
        DEPTH~~9.1~~4.3~~4.3
        HEIGH~~3.6~~2.4~~2.4

     NOTES:
        [Floor height] is the height of the floor of each room
        with respect to some reference datum (e.g., the
        ground).

        [Room width], [Room depth], and [Room height] are the
        dimensions of each room.

        The number of values in each line must equal the number
        of rooms specified for NROOM.

2.4 Connections

INPUT:

     HVENT [From room number] [To room number] [Opening
     width (m)] [Opening height (m)] [Sill height (m)]

EXAMPLE:

     HVENT~1~~2~~1.1~~2.1~~0.0
     HVENT~1~~3~~1.1~~2.1~~0.0
     HVENT~2~~4~~1.3~~2.1~~0.6

NOTES:

     [From room number] is the room number from which the
     smoke is assumed to be originating.

     [To room number] is the room number to which the smoke
     is assumed to be flowing. The program will
     automatically correct the flow direction if the assumed
     direction is incorrect.

     [Opening width] is the width of the opening.

     [Opening height] is the height of the top of the
     opening above the floor.

     [Sill height] is the height of the bottom of the
     opening (sill) above the floor.

     Openings to the outside are included as openings to the
     room with a number 1 greater than the number of rooms
     specified for NROOM, which in the above example
     is room number 4.

2.5 Thermophysical Properties of Enclosing Surfaces

INPUT:
```
[Label]
COND~ [Conductivity (kW/(m·K))]
SPHT~ [Specific heat (kJ/(kg·K))]
DNSTY [Density (kg/m³)]
THICK [Thickness (m)]
EMISS [Emissivity]
```

EXAMPLE:
```
CEILI
COND~~.00018~.00018~.00018
SPHT~~.9~~~~~.9~~~~~.9
DNSTY~790.~~~790.~~~790.
THICK~.016~~~.016~~~.016
EMISS~.9~~~~~.9~~~~~.9

WALLS
COND~~.00018~.00018~.00018
SPHT~~.9~~~~~.9~~~~~.9
DNSTY~790.~~~790.~~~790.
THICK~.016~~~.016~~~.016
EMISS~.9~~~~~.9~~~~~.9

FLOOR
COND~~.0017~~.0017~~.0017
SPHT~~1.0~~~~1.0~~~~1.0
DNSTY~2200.~~2200.~~2200.
THICK~.15~~~~.15~~~~.15
EMISS~.9~~~~~.9~~~~~.9
```

NOTES:
CEILI, WALLS, and FLOOR are the required [Labels] for the ceiling, walls, and floor respectively.

The number of values in each line should equal the number of rooms specified for NROOM except as noted below.

COND, SPHT, DNSTY, THICK and EMISS are the labels for the thermophysical properties of the enclosing surfaces (walls, ceiling or floor). If the thermophysical properties of the enclosing surfaces are not included FAST will treat them as adiabatic (no heat transfer). Since most of the heat transfer is through the ceiling and the conduction calculation takes more than half of the computation time, it is recommended that initial calculations be made using the ceiling only. Adding the walls generally makes little change in the results and the floor contribution is negligible. Clearly, there are cases where the above generalization does not hold, but it may prove to be a useful screening technique.

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It is possible to account for enclosing surfaces
composed of a maximum of three layers of different
materials. To do this, the thermophysical parameters
are separated by "/" for each surface and each
compartment. As an example using the sample data
above, the ceiling in compartment 2 is divided into
three layers. Each of these layers has the same
thickness but the properties of the center layer differ
from the outer two layers.

```
CEILI
COND~~.00018~.00018/.00004/.00018~.00018
SPHT~~.9~~~~~.9/.8/.9~~~~~.9
DNSTY~790.~~~790./50./790.~~~790.
THICK~.016~~~.016/.08/.016~~~.016
EMISS~.9~~~~~~~~~~.9~~~~~~~~~~.9
```

Note there is only a single value for the emissivity
and it applies to the interior surface of the
enclosing surface.

2.6   Fire Specifications

LFBO

    INPUT:
        LFBO~ [Room of fire origin] [Description]

    EXAMPLE:
        LFBO~~2~ROOM OF FIRE ORIGIN

    NOTES:
        [Room of fire origin] is the room number in which the
        fire originates.

        [Description] is an optional user comment and has no
        effect on the program, but serves to clarify the data
        file to the user.

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LFBT

    INPUT:
        LFBT~ [Fire type] [Description]

    EXAMPLE:
        LFBT~~1~TYPE OF FIRE (SPECIFIED FIRE)

    NOTES:
        [Fire type] is the type of fire and in version 17 of
        FAST is limited to:

            1 = SPECIFIED FIRE

        [Description] is an optional user comment and has no
        effect on the program, but serves to clarify the data
        file to the user.

LFPOS

    INPUT:
        LFPOS [Fire position] [Description]

    EXAMPLE:
        LFPOS~1~FIRE POSITION (CENTER)

    NOTES:
        [Fire position] is the area of the room in which the
        fire originates and in version 17 of FAST is limited to
        the following:

            1 = CENTER OF ROOM
            2 = CORNER OF ROOM
            3 = ALONG WALL

        The fire position is used to account for the entrainment
        rate of the plume, which depends on the location of the
        plume within the compartment. Fire positions 2 and 3
        should only be used when the fire is very close to the
        corner or wall respectively.

        [Description] is an optional user comment and has no
        effect on the program, but serves to clarify the data
        file to the user.

INPUT:
      CHEMI [Fraction of pyrolysis] [Fraction of water]
      [Fraction of carbon] [Fraction of hydrogen] [Fraction
      of oxygen] [Heat of combustion (kJ/kg)] [Initial fuel
      temperature (K)]

EXAMPLE:
      CHEMI~1.0~~0.0~~0.0~~0.0~~0.0~18000~300

NOTES:
      [Fraction of pyrolysis] is the mass fraction of fuel
      which actually burns. The remaining fuel is considered
      to be char. For version 17 of FAST, use a value of
      1.0, see discussion below.

      [Fraction of water] is the mass fraction of water in
      the fuel by weight. For version 17 of FAST, use a
      value of 0.0, see discussion below.

      [Fraction of carbon], [Fraction of hydrogen], and
      [Fraction of oxygen] are the respective mass fractions
      of carbon, hydrogen, and oxygen in the fuel by weight.
      For version 17 of FAST, use a value of 0.0 for these
      inputs, see discussion below.

      [Heat of combustion] is the effective net heat of
      combustion of the fuel.

      [Initial fuel temperature] is the initial temperature
      of the fuel and for version 17 of FAST should be the
      ambient temperature specified for TAMB.

      This input line provides for future capabilities of the
      program. For version 17 of FAST a value of 1.0 should
      be used for the [Fraction of pyrolysis] and 0.0 should
      be used for the [Fraction of water], [Fraction of
      carbon], [Fraction of hydrogen] and the [Fraction of
      oxygen].

LFMAX

INPUT:
      LFMAX [Number of intervals] [Description]

EXAMPLE:
      LFMAX~5~NUMBER OF INTERVALS OF FIRE GROWTH

NOTES:
      [Number of intervals] is the number of time intervals
      for the mass loss rate, fuel height and species inputs.
      The mass loss rate, fuel height and species are entered
      as series of points with respect to time. This is
      referred to in this document as a specified fire. The
      program performs a linear interpolation between these
      points to determine the values at all times. A
      sufficient number of intervals should be selected to
      provide a reasonable approximation (using straight line
      segments) for the input variables which specify the
      fire. A graphical example of this is shown in Figure
      2. The mass loss rates P1-P6 are specified over the
      time intervals I1-I5. The number of points specified
      must be one greater than the number of time intervals.
      For example, if there are six mass loss points there
      should be a total of five time intervals (or one
      interval between every two consecutive points). The
      maximum number of intervals allowed in version 17 of
      FAST is 21.

      [Description] is an optional user comment and has no
      effect on the program, but serves to clarify the data
      file to the user.

FTIME

    INPUT:
        FTIME [Time interval (sec)]

    EXAMPLE:
        FTIME~60~30~120~45~60

    NOTES:
        [Time interval] is the time between each point (mass
        loss rate, fuel height and species) specified for the
        fire. The total duration of the fire is the sum of the
        time intervals which in the example above is 315
        seconds. This time is independent of the simulation
        time which is specified for TIMES. If the simulation
        time is longer than the total duration of the fire, the
        final values specified for the fire (mass loss rate,
        fuel height and species) will be continued until the
        end of the simulation.

        The number of time interval values must equal the
        number of intervals specified for LFMAX.

FMASS

    INPUT:
        FMASS [Mass loss rate (kg/s)]

    EXAMPLE:
        FMASS~0~.01~.1~.01~.01~0

    NOTES:
        [Mass loss rate] is the rate at which fuel is pyrolyzed
        at times corresponding to each point of the specified
        fire (See Figure 2.).

        The number of mass loss rate values must be 1 greater
        than the number of intervals specified for LFMAX.

FHIGH

INPUT:
    FHIGH [Fuel height (m)]

EXAMPLE:
    FHIGH~0.5~0.5~0.5~0.4~0.4~0.4

NOTES:
    [Fuel height] is the height of the base of the flames
    above the floor of the room of fire origin for each
    point of the specified fire.

    The number of fuel height values must be 1 greater than
    the number of intervals specified for LFMAX.

2.7   Species Production

INPUT:
    [Label] [Species (kg/kg)]

EXAMPLE:
    CO~~~~.02~.02~.02~.02~.02~.02 ⁻
    OD~~~~.02~.02~.02~.02~.02~.02
    CT~~~~1.0~1.0~1.0~1.0~1.0~1.0

NOTES:
    [Species] is an optional input and specifies the mass
    production rates of each of the constituents for each
    point of the specified fire.

    Available [Labels] are as follows:
    N2~~~   =   NITROGEN PRODUCTION RATE
    O2~~~   =   OXYGEN PRODUCTION RATE
    CO2~~   =   CARBON DIOXIDE PRODUCTION RATE
    CO~~~   =   CARBON MONOXIDE PRODUCTION RATE
    HCN~~   =   HYDROGEN CYANIDE PRODUCTION RATE
    HCL~~   =   HYDROGEN CHLORIDE PRODUCTION RATE
    TUHC~   =   TOTAL UNBURNED HYDROCARBONS
    H2O~~   =   WATER PRODUCTION RATE
    OD~~~   =   SMOKE DENSITY (SOOT PRODUCTION)
    CT~~~   =   CONCENTRATION-TIME PRODUCT

    Units for [Species] are kilogram of species produced
    per kilogram of fuel burned. The input for CT is the
    kilograms of "toxic" combustion products produced per
    kilogram of fuel burned.

    The number of values for each specie must be 1 greater
    than the number of intervals specified for LFMAX.

2.8   Output File

INPUT:
        DUMPR [Dump file]

EXAMPLE:
        DUMPR~FAST1.DAT

NOTES:
        [Dump file] specifies the name of the file (up to 17
        characters) to which the program outputs for plotting
        are written.   The dump file is read by the program
        FASTPLOT which generates plots of the output.

        [Dump file] is an optional input.   If omitted, the file
        for use by the plotting routine FASTPLOT will not be
        generated.   A discussion of the program FASTPLOT is
        given in reference [1].

3. DESCRIPTION OF THE OUTPUT

The output of the FAST program consists of two major parts. The first is a summary of the input data and the second consists of the calculated results at the end of each print interval. A sample of the program output is shown in Appendix B. Due to the effect of the computer's internal precision on the solution of the equations, it is expected that the results from other computers will differ slightly from those found in Appendix B. The output is labeled and most of it is self explanatory. There are however, a number of abbreviations used which are explained in the following sections along with a general description of the output. The outputs pertaining to each of the compartments are listed across the page beginning with compartment one in the left most column and proceeding to the right to the highest number compartment.

3.1 Summary of Input Data

The summary of input data is divided into three sections. These are geometrical data, thermophysical properties and the fire specifications.

3.1.1 Geometrical Data

This section lists the run title, the total number of compartments, the maximum number of openings per pair of compartments and the width, depth, height, area and volume for

each compartment. It also gives the ceiling and floor height with respect to the reference datum. This is followed by the connections between the compartments. Each compartment is listed vertically down the page and horizontally across the page and the connections between compartments are given at the intersection of the vertical and horizontal lists. The final compartment in the horizontal list is the exterior space. The parenthesized numbers in the vertical compartment list are the number of openings for each compartment. For example, if the maximum number of openings between any two compartments is three, there would be three parts for each compartment in the vertical list. Each part consists of the following:

1) opening width (BW) (m)

2) height of top of opening above floor (HH) (m)

3) height of bottom of opening above floor (HL) (m)

4) height of top of opening above reference datum (HHP) (m)

5) height of bottom of opening above reference datum (HLP) (m)

3.1.2 Thermophysical Properties

This section lists the thermophysical properties of the ceiling, floor, upper and lower walls respectively for each compartment. Although the thermophysical properties of the upper and lower walls are the same, they are presented separately to correspond to the temperature of the upper and lower temperature

layers of the compartment. The thermophysical properties are the thermal conductivity, specific heat, density, thickness and emissivity.

3.1.3 Fire Specifications

This section consists of three parts. The first part lists the compartment number of the room of fire origin, the time step used in calculating the results, how often output is to be printed, the number of intervals for which the mass loss rate is specified, the total time over which the results will be printed, the fire location within the room of origin, and the fire type.

The second part lists the initial fuel temperature, the ambient air temperature, the ambient sea level reference pressure and the effective heat of combustion.

The third part lists for each specified point of the fire, the mass loss rate of the burning fuel, the height of the base of the fire with respect to the floor, and the fractional production rates of the species. Also listed is the duration of each time interval.

3.2 Results of Calculations

The final part of the output consists of the calculated results at the end of each print interval. The first line of the output is the simulation time. For the sample output in Appendix

B, the results have only been included for times 0, 60, and 360 seconds. Following the time are the temperatures of the upper (U.TEMP) (K) and lower (L.TEMP) (K) layers, the upper layer volume (U.VOLUM) (m^3) and thickness (U.DEPTH) (m), and the temperatures of the ceiling (CE.TEMP) (K), upper (UW.TEMP) (K) and lower (LW.TEMP) (K) walls, and the floor (FL.TEMP) (K).

Next is the flow rate of combustion products and entrained air into the upper layer from the plume (EMS) (kg/s), the pyrolysis rate of the fuel (EMP) (kg/s), the enthalpy release rate of the fire (QF) (kW), the total radiant heat transfer to the upper layer (QR) (kW), the total convective heat transfer from the surfaces surrounding the layers to the upper and lower layers respectively (QC) (kW), and the difference between the current pressure and the initial pressure at the floor (Pres) (kpa).

The final part of the results consists of the species concentration for each compartment. The total mass of each specie in the upper layer is given for each compartment (kg). Depending on the specie, a concentration (PPM) or opacity (1/M) is also given. For CT, the concentration-time product, only the time integrated (from time=0) concentration (mg-min/l) for the upper layer in each compartment is given. The use of this time integrated concentration is discussed in reference [5].

4. REFERENCES

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[3] Gross, D., Data Sources for Parameters used in Predictive Modeling of Fire Growth and Smoke Spread. Nat. Bur. Stand. (U.S.) NBSIR 85-3223; 1985 September.

[4] American National Standard Programming Language FORTRAN, ANSI X3.9-1978. New York: American National Standards Institute; 1978. 434 p.

[5] Bukowski, R.W., Quantitative Determination of Smoke Toxicity Hazard - A Practical Approach for Current Use. Proceedings of the First International Symposium on Fire Safety Sciences. Gaithersburg, MD; 1985. to be published.
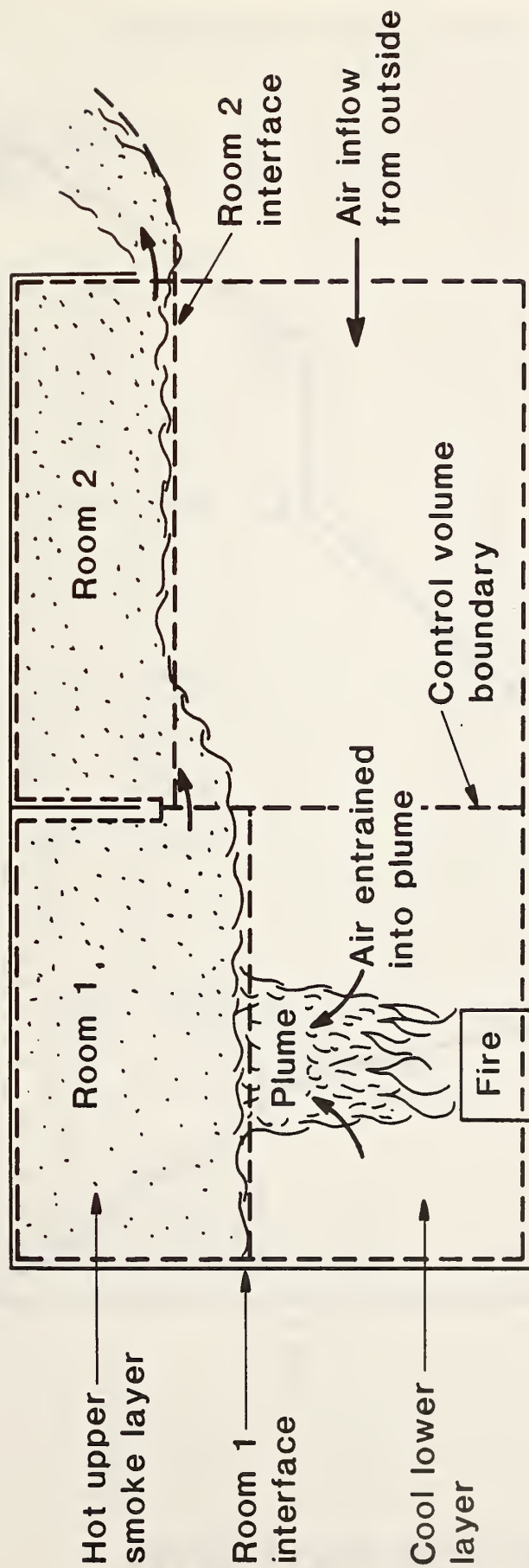
Figure 1. Schematic of upper and lower layer control volumes

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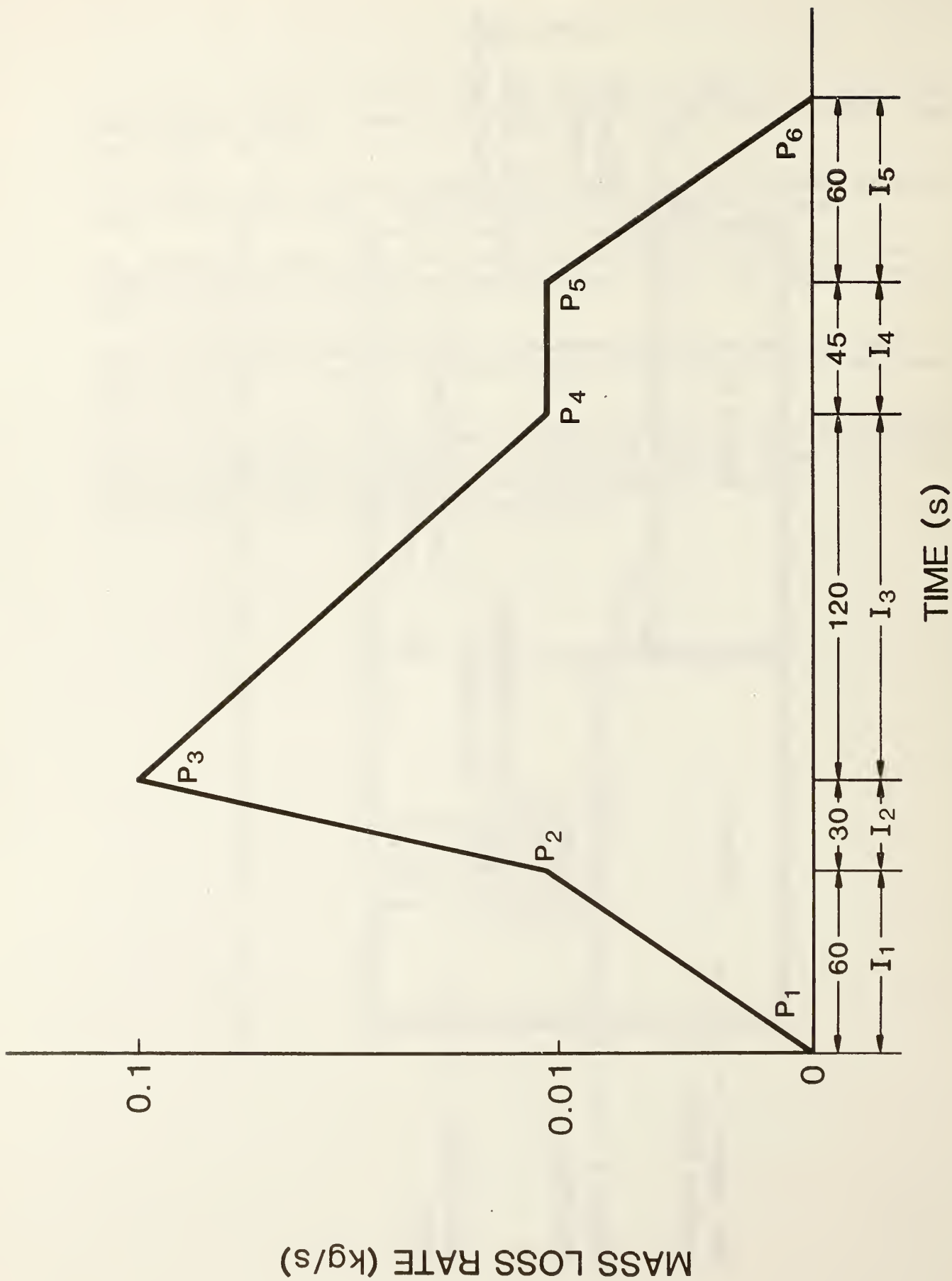
Figure 2.   Example of mass loss data for a specified fire

```
VERSN   017 BUILDING XYZ
TIMES 360 30 0
NROOM 3
NMXOP 1
TAMB 300
HI/F    0.0    0.0    0.0
WIDTH   6.1    4.6    4.6
DEPTH   9.1    4.3    4.3
HEIGH   3.6    2.4    2.4
HVENT 1   2   1.1    2.1    0.0
HVENT 1   3   1.1    2.1    0.0
HVENT 2   4   1.3    2.1    0.6
CEILI
COND    .00018 .00018 .00018
SPHT    .9      .9      .9
DNSTY 790.    790.    790.
THICK .016    .016    .016
EMISS .9      .9      .9
WALLS
COND    .00018 .00018 .00018
SPHT    .9      .9      .9
DNSTY 790.    790.    790.
THICK .016    .016    .016
EMISS .9      .9      .9
FLOOR
COND    .0017   .0017   .0017
SPHT  1.0     1.0     1.0
DNSTY 2200.   2200.   2200.
THICK .15     .15     .15
EMISS .9      .9      .9
LFBO   2 ROOM OF FIRE ORIGIN
LFBT   1 TYPE OF FIRE (SPECIFIED FIRE)
LFPOS 1 FIRE POSITION (CENTER)
CHEMI 1.0   0.0   0.0   0.0   0.0 18000 300
LFMAX 5 NUMBER OF INTERVALS OF FIRE GROWTH
FTIME 60 30 120 45 60
FMASS 0 .01 .1 .01 .01 0
FHIGH 0.5 0.5 0.5 0.4 0.4 0.4
CO      .02 .02 .02 .02 .02 .02
OD      .02 .02 .02 .02 .02 .02
CT      1.0 1.0 1.0 1.0 1.0 1.0
```

BUILDING XYZ

TOTAL COMPARTMENTS =   3
MAXIMUM OPENINGS PER PAIR =   1

FLOOR PLAN

WIDTH	6.1	4.6	4.6
DEPTH	9.1	4.3	4.3
HEIGHT	3.6	2.4	2.4
AREA	55.5	19.8	19.8
VOLUME	199.8	47.5	47.5
CEILING	3.6	2.4	2.4
FLOOR	0.0	0.0	0.0

CONNECTIONS

1 (1)	BW=	0.0	1.1	1.1	0.0
	HH=	0.0	2.1	2.1	0.0
	HL=	0.0	0.0	0.0	0.0
	HHP=	0.0	2.1	2.1	0.0
	HLP=	0.0	0.0	0.0	0.0
2 (1)	BW=	1.1	0.0	0.0	1.3
	HH=	2.1	0.0	0.0	2.1
	HL=	0.0	0.0	0.0	0.6
	HHP=	2.1	0.0	0.0	2.1
	HLP=	0.0	0.0	0.0	0.6
3 (1)	BW=	1.1	0.0	0.0	0.0
	HH=	2.1	0.0	0.0	0.0
	HL=	0.0	0.0	0.0	0.0
	HHP=	2.1	0.0	0.0	0.0
	HLP=	0.0	0.0	0.0	0.0

CEILING

COND =	1.800E-04	1.800E-04	1.800E-04
SPHT =	9.000E-01	9.000E-01	9.000E-01
DNSTY=	7.900E+02	7.900E+02	7.900E+02
THICK=	1.600E-02	1.600E-02	1.600E-02
EMISS=	9.000E-01	9.000E-01	9.000E-01

FLOOR

COND =	1.700E-03	1.700E-03	1.700E-03
SPHT =	1.000E+00	1.000E+00	1.000E+00
DNSTY=	2.200E+03	2.200E+03	2.200E+03
THICK=	1.500E-01	1.500E-01	1.500E-01
EMISS=	9.000E-01	9.000E-01	9.000E-01

```
   UPPER WALL

COND =        1.800E-04    1.800E-04    1.800E-04
SPHT =        9.000E-01    9.000E-01    9.000E-01
DNSTY=        7.900E+02    7.900E+02    7.900E+02
THICK=        1.600E-02    1.600E-02    1.600E-02
EMISS=        9.000E-01    9.000E-01    9.000E-01

   LOWER WALL

COND =        1.800E-04    1.800E-04    1.800E-04
SPHT =        9.000E-01    9.000E-01    9.000E-01
DNSTY=        7.900E+02    7.900E+02    7.900E+02
THICK=        1.600E-02    1.600E-02    1.600E-02
EMISS=        9.000E-01    9.000E-01    9.000E-01
```

```
FIRE ROOM NUMBER IS     2
TIME STEP IS  1.00 SECONDS
PRINT EVERY  60 TIME STEPS
NUMBER OF FIRE INTERVALS =       5
TOTAL TIME INTERVAL =   360
FIRE SOURCE =    1
FIRE TYPE = SPECIFIED
```

```
INITIAL FUEL TEMPERATURE (K) =                    300.
AMBIENT AIR TEMPERATURE (K) =                     300.
AMBIENT REFERENCE PRESSURE (kPa) =             101.30
EFFECTIVE HEAT OF COMBUSTION (KJ/KG) =         18000.
```

```
FMASS=   0.00       1.00E-02   0.10      1.00E-02   1.00E-02   0.00
FHIGH=   0.50       0.50       0.50      0.40       0.40       0.40
   CO=   2.00E-02   2.00E-02   2.00E-02  2.00E-02   2.00E-02   2.00E-02
   OD=   2.00E-02   2.00E-02   2.00E-02  2.00E-02   2.00E-02   2.00E-02
   CT=   1.0        1.0        1.0       1.0        1.0        1.0
FTIME=   60.        30.        1.20E+02  45.        60.
```

```
TIME =    0.0 SECONDS.

U.TEMP.            300.0        300.0        300.0
L.TEMP.            300.0        300.0        300.0
U.VOLUM              0.2          0.0          0.0
U.DEPTH              0.0          0.0          0.0
CE.TEMP            300.0        300.0        300.0
UW.TEMP            300.0        300.0        300.0
LW.TEMP            300.0        300.0        300.0
FL.TEMP            300.0        300.0        300.0
EMS(I)=          0.000E+00   0.000E+00   0.000E+00
EMP(I)=          0.000E+00   0.000E+00   0.000E+00
 QF(I)=          0.000E+00   0.000E+00   0.000E+00
 QR(I)=          0.000E+00   0.000E+00   0.000E+00
 QC(I)=          0.000E+00   0.000E+00   0.000E+00
                 0.000E+00   0.000E+00   0.000E+00
Pres(kpa)        0.000E+00   0.000E+00   0.000E+00

              Upper layer species concentration

   CO MASS  !    0.000        0.000        0.000
      PPM   !    0.000        0.000        0.000


   OD MASS  !    0.000        0.000        0.000
      1/M   !    0.000        0.000        0.000


   CT mg-m/l !   0.000        0.000        0.000
```

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```
TIME =    60.0 SECONDS.

U.TEMP.            321.7         440.6         300.0
L.TEMP.            300.2         300.8         300.3
U.VOLUM            37.9          15.3           0.0
U.DEPTH            0.7           0.8            0.0
CE.TEMP            301.6         316.4         300.0
UW.TEMP            301.6         316.4         300.0
LW.TEMP            300.1         301.3         300.0
FL.TEMP            300.0         300.2         300.0
EMS(I)=        0.000E+00     7.910E-01     0.000E+00
EMP(I)=        0.000E+00     1.000E-02     0.000E+00
 QF(I)=        0.000E+00     1.800E+02     0.000E+00
 QR(I)=       -1.836E+00    -8.550E+00    -6.990E-03
 QC(I)=       -8.981E+00    -3.598E+01    -9.722E-03
              -1.090E-03    -3.904E-03    -3.226E-02
Pres(kpa)      2.190E-01    -5.125E-01    -4.926E-02

              Upper layer species concentration

   CO MASS   :    1.489E-03     2.659E-03     0.000
      PPM    :      33.7          205.         0.000


   OD MASS   :    1.489E-03     2.659E-03     0.000
      1/M    :      0.137         0.609        0.000


   CT mg-m/l :      0.811         4.54         0.000
```

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```
TIME =   360.0 SECONDS.

U.TEMP.            348.4        345.9        338.7
L.TEMP.            302.2        318.8        302.1
U.VOLUM            137.5         17.3         28.0
U.DEPTH              2.5          0.9          1.4
CE.TEMP            320.4        351.6        312.8
UW.TEMP            320.4        351.6        312.8
LW.TEMP            306.2        324.3        303.1
FL.TEMP            301.1        304.5        300.4
EMS(I)=          0.000E+00  1.835E-01  0.000E+00
EMP(I)=          0.000E+00  0.000E+00  0.000E+00
 QF(I)=          0.000E+00  3.000E+00  0.000E+00
 QR(I)=         -5.147E+00 -4.475E-01 -1.445E+00
 QC(I)=         -2.018E+01  2.910E-01 -6.271E+00
                 3.123E-01  3.596E-01  3.589E-02
Pres(kpa)       -9.113E-01 -7.843E-01 -6.492E-01

            Upper layer species concentration

  CO MASS   !   3.401E-02    2.433E-03    7.398E-03
     PPM    !    230.         130.         239.


  OD MASS   !   3.401E-02    2.433E-03    7.398E-03
     1/M    !    0.866        0.491        0.924


  CT mg-m/l !    53.8         64.5         45.7
```

U.S. DEPT. OF COMM. **BIBLIOGRAPHIC DATA** **SHEET** *(See instructions)*	1. PUBLICATION OR REPORT NO. NBSIR 85/3284	2. Performing Organ. Report No.	3. Publication Date December 1985

4. TITLE AND SUBTITLE

User's Guide for FAST

5. AUTHOR(S)

William D. Walton, Steven R. Baer, and Walter W. Jones

6. PERFORMING ORGANIZATION *(If joint or other than NBS, see instructions)* **NATIONAL BUREAU OF STANDARDS** **U.S. DEPARTMENT OF COMMERCE** **GAITHERSBURG, MD 20899**	7. Contract/Grant No. 8. Type of Report & Period Covered

9. SPONSORING ORGANIZATION NAME AND COMPLETE ADDRESS *(Street, City, State, ZIP)*

10. SUPPLEMENTARY NOTES

☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

11. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)*

FAST is a multicompartment zone type computer model which predicts the smoke hazard development in each compartment based on a description of the compartments and the fire. A FORTRAN program has been written for the model. This user's guide provides a detailed description of the data input requirements and the output produced by version 17 of the program. Also included are sample program input and output.

12. KEY WORDS *(Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)*

Compartment fires; computer programs; fire growth; manuals; mathematical models; room fires; smoke; toxicity

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